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ABSTRACT

This paper examines the validity of diagnostic categories frequently used to classify children with severe language disorders by determining the relationship of the categories to independently derived developmental, psychological, and medical variables. It is argued that the classification systems currently available too often fail to achieve the goals of description and usefulness in promoting effective treatment. Case histories and other data from 82 children with severe language disorders were used to assign each child to one of seven diagnostic categories. The 82 cases were then regrouped on the basis of 32 clinical variables using a step-wise clustering procedure. The seven original categories collapsed to only two definable clusters. A repetition of the analysis using a larger sample and different variable set resulted in similar clusters. The variables which define these clusters are discussed, as well as the resulting implications for assessment procedures in general. (Author/AM)

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A STATISTICAL TEST OF THE VALIDITY OF DIAGNOSTIC CATEGORIES USED IN CHILDHOOD LANGUAGE DISORDERS: IMPLICATIONS FOR ASSESSMENT PROCEDURES[1]

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INTRODUCTION

The purpose of the present study was to test the validity of frequently used diagnostic categories by determining their relationship to independently derived developmental, psychological and medical variables. Historically, language delays associated with deafness, neurological disorders, mental retardation and severe emotional or autistic disorders, have been viewed as substantially different from one another. This principle is partly responsible for the segregation of children into treatment groups based primarily on assumed etiology.

This traditional viewpoint is currently under attack from two directions. On the one hand, the increased application of behavior therapies has tended to de-emphasize etiological distinctions in favor of greater attention to the specific individual's symptoms and their modification. On the other hand, recent linguistic analysis of deviant language systems in both aphasic and mentally retarded children seems to indicate that delayed language is just that - a language system characteristic of an earlier stage of normal development, rather than a system which is in some sense qualitatively different from normal development. (Morehead and Ingram, 1970; Lackner, 1968).

Nevertheless, many clinicians continue to believe that there are clearly identifiable patterns of behavior and performance which permit the classification of children into distinctive diagnostic categories. While this approach has a certain face validity, the classification of disorders is of little importance unless that system of classification segregates children with respect to variables which are related in some important fashion to treatment options.

From the clinical standpoint, defining differences between various types of communicative disorders can be considered a multi-level problem. The first order of business is to rule out the most frequent and obvious contributors to language delay: hearing loss, gross mental retardation, severe brain damage, and severe emotional disorder. Frequently, however, the cause or causes of language delay are obscure, either because multiple etiology is responsible or because no single finding seems sufficient to explain the absence of language. These are the types of cases which are usually referred to diagnostic centers; they represent the majority of cases seen at this Institute.

Considerable experience with such cases has led us to make certain observations about the classification of disorders. First, the most striking behavioral characteristics of a child are not reliable bases of classification. For example, bizarre behavior can act as a mask which often obscures the nature and degree of linguistic deviation. Second, medical

etiology by itself also fails as an effective basis for grouping linguistic disorders. Third, a wealth of data may be obtained from close psychological and language observation and testing, but no reliable guidelines currently exist for interpreting and relating the results of such evaluations for purposes of classification. Finally, the problem of classification is not trivial. If it is possible to find a "natural" classification system which both assists in planning treatment and permits reasonable predictions of the outcome of specific cases, then the search for such categories should be worthwhile.

The classification schemes for communication disorders which do exist include those which reflect distinctive behavior patterns as well as presumed or confirmed etiology. Typically, these categories are described by terms such as "organic", "neurologically handicapped", "aucistic", "aphasic", "hard-of-hearing", etc. While these labels usually refer to some empirical base, they lack utility for at least two reasons. First, their characteristics are not universally defined. Second, a single child may legitimately receive multiple labels. In the latter case there is frequently no clear basis for deciding which label sould serve as the principle descriptor.

Another kind of categorization is typified by the terms which educators use in assigning children to special classroom environments. Classroom labels include, "educable mentally retarded", "educationally handicapped", "emotionally disturbed", "aphasic", etc. The intended function of this kind of system is to segregate children on some appropriate basis in order to provide proper remedial education and training. However, there is evidence from other data collected as part of this study that to a considerable degree social and economic factors indirectly determine the assignments of children to particular treatment environments.

Once assigned to a particular type of classroom or special program, the school age child often comes to be regarded as a typical example of whatever category of disorders serves to describe that type of class. The individuality conferred by a detailed medical diagnostic statement is lost. For example, the child diagnosed by a clinical diagnostic team as primarily brain-damaged may turn up re-diagnosed as mentally retarded by virtue of class placement.

The foregoing example underscores the difficulties posed by ill-defined, and improperly used classifications of children with communicative disorders. There is no way, for instance, to determine to what degree parents or teachers contribute to "shifts" in classification because it is not possible to tie the categories used by either group to a clearly specified system of medical (or other) diagnostic categories. Nevertheless, data clearly indicate that such shifts in labeling do occur.

It should be pointed out, however, that the effects of shifting diagnostic labels are not necessarily negative. Different classification systems may have equal utility, depending on the success of each system in achieving the objectives for which it is intended. Usually we assess the utility of such systems by their descriptive or explanatory power, and by their usefulness in guiding children toward effective treatment. It is argued here that the classification systems currently available too often fail to achieve these reasonable goals.

DISCRIMINANT AND FACTOR APPROACHES TO CLASSIFICATION

The preceding section focused on the kinds of problems which may result when children with communicative disorders are described using rather broad descriptive categories. At the same time, there have been a considerable number of approaches to the problem of narrower classification within broad categories such as those mentioned in the preceding section. Such classification schemes have been supported by theoretical constructs, clinical observations, and various statistical procedures.

For example, both theoretical and clinical origins form the basis of Myklebust's (1954) classification of auditory disorders in children. In that and subsequent work, Myklebust has keyed a variety of communicative disorders to differences in auditory system behavior and symptomatology.

More recently, Schuell (1967) derived factors based on behavioral and psychological variables which differentiate five types of adult aphasic syndromes. Darley, et al., (1969a, 1969b) have defined, on a statistical basis, the deviant speech dimensions characteristic of various dysarthric disorders.

Other investigatators have focused on the problem of differentiating between groups with respect to a single clinical or cognitive variable. For instance, Wheeler, Burke, and Reitan (1963) and Wheeler and Reitan (1963) have applied discriminant analysis techniques in predicting brain damage in adults from a variety of behavioral variables. Within the brain-damage category, left damage, right damage, diffuse damage, and right vs left damage were discriminated with high accuracy on the basis of behavioral variables derived mostly from standardized tests.

In studies of the sort cited above the data are usually submitted to some kind of factor analytic procedure followed by discriminant analysis. This strategy of data reduction results in clustering of correlated variables (factors) and subsequent identification of the clinical types these clusters represent.

The choice of a particular method of data analysis has sometimes been a subject of controversy. But it has been demonstrated that any of several clustering procedures produce quite similar results given the same data set (Solomon, 1970). The choice of one procedure over another must ultimately reflect the objectives of each particular investigation.

The statement of objectives must address itself to the degree of completeness desired in the data analysis. Solomon (1970) points out that total enumeration of all data partitions and subsequent selection of optimal clustering is usually unacceptable because of the extravagant use of computer time and its attendant expense. Step-wise clustering schemes avoid extravagance by serial selection of the "best" available groupings, but at the cost of possibly ignoring some configurations which might improve the results. These latter deficiences may be offset to some degree by applying "expertise" in interpreting the resulting clusters.

Another choice to be made is whether to evolve clusters of variables or clusters of individuals. The usual approach (e.g., studies cited above) is to rotate variable scores obtained on a limited subject population. The clusters formed are then identified by the saliency of the variables they contain. Ideally, it is then possible to view a profile of variable scores for any individual subject, whether included in the original analysis or acquired subsequent to the analysis, and identify those factors which are most descriptive of that individual.

When cluster analysis of variables rather than individuals is undertaken, the nature of the subject sample is critical in certain respects. A subject population which is, in some relative sense, more narrowly defined on the basis of *a priori* clinical expertise should be expected to produce fewer variable clusters than a more widely diversified clinical sample. For that reason, *a priori* clinical labeling of subjects can have significant influences on the results of subsequent factor analyses of variable scores obtained on those same subjects.

The present study differs from most other factor studies because it has attempted to address, in a broad sense, the issue of validity in "expert" clinical labeling. In order to do this, it has been desirable to focus on groupings of individuals rather than clusters of variables. In simplest terms, the following study tested the validity of seven *a priori* diagnostic categories used to describe children with developmental, cognitive-linguistic disorders. The stability of these categories was tested in two procedures by clustering individuals with respect to two different sets of variables. The derived clusters were then compared with the *a priori* categories. Variables which were primarily responsible for differentiating the newly derived clusters were subsequently identified.

CLUSTER ANALYSIS I

In the first stage of the study, children referred to the Institute for Childhood Aphasia because of severe language impairment were assessed and assigned into one of seven primary diagnostic categories on the basis of their case histories, test data, and predominant clinical impression. The judgments were made by direct observations of the staff pediatric neurologist and psychologist, and by contributed information of a psychometrist and language clinician.

Subjects. Although more than two hundred (200) children were seen, many were so severely and multiply impaired as to provide no clear basis for a primary diagnosis. Only eighty-two (82) children, age range 3 to 8 years, were assignable into one of 7 primary diagnostic groups. The distribution of these children among the a priori diagnostic categories is shown in Table 1. Children who could not be assigned to one of these categories without reservation were omitted from this phase of the study. Therefore, the first sample for analysis consisted only of those children who could be assigned with high reliability.

Table 1. A Priori Diagnostic Categories Used in Cluster Analysis I

Diagnostic Category	Number of Children
1. Mentally retarded	17
2. Severe hearing impairment	10
3. Neurologically handicapped/aphasic	30
4. Oral apraxic	5
5. Dysarthric	4
6. Maturational lag (organic)	9
7. Autistic	7

Variables. Each of the 82 children was rated as deviant or normal on each of 32 variables derived from observations and data collected from medical histories, psychological testing, and speech and language evaluations.

The 32 variables are listed in Table 2. Some measurements, such as those under the medical heading, were based on fairly objective clinical assessment (laterality, hearing impairment, EEG). Others were obtained from histories (delayed motor development, pre- and peri-natal CNS insult, etc.) However, the largest group of variables, those obtained from psychometric and language evaluations, were derived from sub-tests of various standardized tests and inventories. For example, a child's rating on Body Image was based on any one, or combination of the following subtests: Goodenough-Draw-A-Man; WISC Manikin; Merrill-Palmer Manikin; Stanford-Binet V, 1 Picture Completion. Various subtests appropriate to the psychological variables in Table 2, as well as the basis for scoring other variables, are shown in the Appendix.

Table 2. Variables Used in Cluster Analysis I

Medical

	1.	Pre- and peri-natal CNS insult
	2.	Post-natal insult
	*3.	Hearing impairment
	4.	EEG abnormality, localized
	*5	EEG abnormality, non-localized
	6.	Laterality (non-right)
	7.	Delayed motor development
	8.	Autonomic disturbances
	9.	Neuro-abnormality

Impaired Psychological Functioning

I	*10.	Discrimination - form and color
I	*11.	Spatial relationships -form and size
I	*12.	Spatial relationships - color pattern
I	*13.	Visual memory - sequencing
	*14.	Body image
	*15.	Abstract categorization - non-verbal
	*16.	Fine motor expression
I	*17.	Vocabulary - identification and reasoning
	*18.	Vocabulary - comprehension
	19.	Auditory discrimination
	20.	Immediate recall - sequencing
	21.	General verbal formulation
I	*22.	Mathematical reasoning

General

	23.	Articulatory deviation
	24.	Adequate oral mechanism
I	*25.	Impaired motor encoding
	*26.	Impaired social development
I	*27.	Adequate intelligence
	28.	Early sound production
	*29.	Autistic manifestation
	30.	Intra-test variability
	*31.	Inter-test variability
	32.	Distractibility

Items marked by an asterick (*) are those which differentiated between two main clusters at .05 probability level. Variables marked by I are items related to general intellectual functioning.

Scoring. For most of the variables it was possible to obtain some kind of numerical score, which, in turn, was convertible to a test-age value. For each variable score, a decision was made as to age-appropriateness. Performance or behavior at or above age level was scored as normal. Contrariwise, below age level performance or behavior was scored as deviant. On the one hand, the use of dichotomous ratings reduces the ability of a test score to reflect the range of differences in "normalcy" or "deviance" among subjects. On the other hand, this treatment of the data is preferable in light of the impediments to valid and reliable testing of children with serious communicative disorders. It is possible to be reasonably confident of the reliability of a test score's direction with respect to a subject's age. But comparisons based on actual test scores, themselves, assume a greater degree of resolution than is warranted when measurements are made on this kind of population.

Cluster Analysis. Dichotomous ratings (normal or deviant) on each variable were input to a step-wise clustering procedure described by Solomon (1970). In this procedure, 82 children were clustered on the basis of 32 variables. The summarization was an 82 x 82 distance matrix, with each cell entry the Mahalanobis distance in a 32-dimensional space between each pair of children. The results of this procedure yielded two distinct clusters. In terms of the original diagnostic categories, the new groupings appeared as follows:

New Cluster	Original Diagnostic Category
Cluster IA	1. Mentally retarded 7. Autistic
Cluster IB	2. Severe hearing impairment 3. Neurologically handicapped/ aphasic 6. Maturational lag

Individuals who were initially classified in categories 4 and 5 were too few to permit certainty in cluster assignment. Independent assessment of the significance of these new groupings was substantiated statistically. A chi-square of 34.67 ($p < .001$) was obtained for the distribution shown, thus supporting, statistically, the visual interpretation of the clusters evolved through this procedure.

Discriminant Analysis. The make-up of the newly derived clusters, with respect to the original diagnostic categories, is not readily explainable on first inspection. Especially perplexing is the combining of mentally retarded and autistic groups. In order to understand the basis of clustering more clearly, a discriminant analysis was executed to determine which of the 32 variables differentiated between the two new clusters. In this analysis, the clusters were accepted, as given, without regard

to original diagnostic category. The N for this procedure was 81 instead of 82 because one individual was not absorbed by either cluster during the analysis.

The results of discriminant analysis are shown in Table 3. The variables are arranged in order of their saliency. Examination of these results indicates that the major basis by which the two clusters of children differ is general performance on intelligence tests, as well as variables highly correlated with (or derived from) intelligence scale subtests. It is particularly noteworthy that most of these subtests are nonverbal. Not only do the derived clusters fail to support the integrity of traditional diagnostic categories, but those clusters also fail to reflect strong differences based on language variables.

Table 3. Discriminant Analysis of Clusters From Cluster Analysis I, Showing Variables Which Differentiate Between Clusters at The .05 Level of Confidence.

	Frequency of Occurrence In Per Cent	
Variable Name	Cluster IA N=35	Cluster IB N=46
Inadequate Intelligence	100.0	0
Impaired Discrimination - form and color	77.1	2.2
Impaired Spatial Relationships - color, pattern	88.6	15.2
Impaired Fine Motor Expression	88.6	32.6
Impaired Motor Encoding	91.4	43.5
Impaired Social Development	77.1	28.3
Impaired Body Image	80.0	32.6
Impaired Mathematical Reasoning	91.4	47.8
Impaired Non-Verbal Abstract Categories	65.7	21.7
Impaired Visual Memory Sequence	82.9	41.3
Impaired Spatial Relationships - form, size	62.9	21.7
Inter-test Variability	25.7	58.7
Impaired Vocabulary - identification, reasoning	97.1	73.9
Impaired Vocabulary - comprehension	72.3	43.5
Hearing Loss	17.1	56.5
EEG Abnormality - non-localized	25.7	6.5
Autistic Manifestations	40.0	17.4

Cluster IA is made up principally of children traditionally described as mentally retarded or autistic. In contrast to Cluster IB, the discriminant analysis shows that Cluster IA consists of children who obtain low scores on intelligence tests, have relatively reduced language as judged by available vocabulary, have poorer social development, and a substantially greater incidence of EEG abnormality and emotional deviance. Cluster IB, by comparison, consists of children with better language capability, but a higher incidence of hearing impairment and test performance variability. This latter cluster included those children who are usually identified as aphasic, but was not composed exclusively of such children.

CLUSTER ANALYSIS II

The preceding data analysis provided results which run contrary to clinical expectations. Most significant was the failure of seven, commonly used diagnostic categories to maintain integral status when tested by objective criteria. The breadth of variables used in that analysis precludes the argument that insufficient data were available for an accurate analysis. As a matter of fact, much of the information used in the statistical analysis was, at the same time, the basis for the clinical judgments which determined the initial categories. If anything, that procedure should have resulted in a bias toward greater correlation between the original categories and those clusters emerging from the analysis.

From another standpoint, it was surprising that the derived clusters did not reflect differences in etiological factors to a greater extent. That would have been indicated most clearly by differences in medical-neurological and medical history variables.

Subjects. In the original analysis, only children who were clearly assignable to diagnostic categories were included. But the failure of those categories to hold up under statistical scrutiny means that many children were excluded from the original analysis on the now questionable assumption that the diagnostic categories used were valid. In the second cluster analysis all children for whom data were available were included in the procedure. This increased the number of subjects used in the analysis from 82 to 138.

Variables. The set of variables was also altered. Measures previously found to be highly correlated with intelligence test scores were eliminated, leaving only one overall estimate of intellectual status. In addition, medical variables were redefined and, in some instances, expanded to include several sub-categories. As a result of these changes, the variable set was reduced to 16 items. These items and their descriptions appear in Table 4.

Table 4. Names and Descriptions of Variables Used in Cluster Analysis II

1. Sex. Male or female.

2. Severe hearing loss. Hearing loss is marked as present when both the three frequency pure-tone average and two best frequency average indicate greater than 50 dB loss in the better ear.

3. Inadequate intelligence. Marked as present when the best standard test IQ score is below 85, preferably on the WISC, Stanford-Binet or Leiter International Performance Scale.

4. Severely inadequate intelligence. Marked as present when the best standard test IQ score is below 65 on preferred tests.

5. Emotionally or behaviorally disturbed - severe. Extreme disruptive or withdrawal behavior observed by the staff, which prevents or seriously interferes with testing or medical examination.

6. Emotionally or behaviorally disturbed - minor. Behavior which interfered with, did not prevent, testing; lack of cooperation, negativism, low frustration tolerance, manifest hostility.

7. Left- or mixed-handedness. A sign of laterality which is marked as present when clear, unambiguous, right-handedness is not present during the earliest evaluation at this Institute.

8. Abnormal EEG. Any significant abnormality in the EEG record as read by qualified medical personnel.

9. Abnormal EEG - symmetrical. Abnormality (spike or wave) is present bilaterally and symmetrically, even though some abnormalities may be unilateral.

10. Abnormal EEG - predominantly left. Abnormal record in which major deviations are not symmetrical, and are seen predominantly on the left side.

11. Maternal age. Marked positive when mother's age was 30 years or more at time of pregnancy.

12. Birth defect or complication - severe. Clear and unambiguous presence of any one or more of the following: hypoxia, anoxia, metabolic or genetic disorders, (e.g., PKU, Downes), neurological signs, seizures or convulsions, need for resusitation, jaundice other than physiologic (in conjunction with serum incompatibility), cranial trauma, placenta previa.

13. Birth defect or complication - minor. Sufficient, but not necessary causes of fetal or infant distress without clear evidence of effects at birth (e.g., Rubella in first trimester, attempted abortion, poisoning, injury to mother during pregnancy).

14. Prematurity or low birth weight. Marked as present when birth weight was less than 5-1/2 pounds.

15. Post-natal trauma or disease. Any post-natal event which could have interferred with intellectual or linguistic development; for example, seizures, convulsions, cranial surgery, fevers, anemia, dehydration, malnutrition, drug reactions resulting in shock, de-oxygenation or head trauma resulting in unconsciousness and/or changes in behavior, coma or unconsciousness of unknown cause, poisoning.

16. High fever(s). High fevers, usually repetitive which were not necessarily complicated or associated with other severe disorders.

As in the first statistical analysis, each variable was scored plus or minus for each child.

Cluster Analysis. The statistical program for this analysis was identical to that used in the first procedure. However, in the present analysis, 138 children were clustered on the basis of a 16 x 16 variable matrix.

Like the first analysis, the results of this second procedure are a challenge to interpretation. Two rather distinct patterns occur in the data; a weak clustering about the 40th pass, and strong clustering at pass number 80.

The weak clustering produced 8 distinct groups, ranging in size from 4 to 9 individuals. A total of only 49 subjects, 35.5% of the total sample are grouped at this stage. The bases of clustering at that point appear to be a combination of sex and various clinical descriptions and findings. Historical or etiological variables further refine cluster characteristics, but in no instance are they, themselves, a strong basis of grouping. These weak clusters are listed and described in Table 5. In that table, strongly differentiating characteristics are underlined for each cluster. Those characteristics discriminate between other clusters and the cluster in which they appear at the .05 confidence level.

Table 5. Weak Clusters and Their Descriptions

Cluster Number	Characteristics
	Male
IIa	Mild emotional disturbance associated with left EEG abnormalities.
IIb	Normal, but with high-risk history.
IIe	Inadequate intelligence and emotionally disturbed with mixed etiology.
IIf	EEG abnormalities associated with inadequate intelligence and mild emotional disturbance.
IIg	Mild emotional disturbance associated with birth defects or complications.
	Female
IIh	Symmetrical EEG abnormalities associated with inadequate intelligence, emotional disturbance and mixed etiology.
	Mixed
IIc	Left EEG abnormalities sometimes associated with inadequate intelligence and post-natal trauma or illness.
IId	Inadequate intelligence and emotional disturbance or unknown etiology.

The weak clusters described above collapse rapidly on subsequent passes. By pass number 80, only one cluster exists. That cluster contains 71 individuals or 51% of the total sample. The remaining 67 individuals are unclustered (or, more properly stated clusters of N=1). On subsequent passes, this established cluster continues to accumulate individuals until the final pass. No other intermediate clusters are formed during those subsequent passes.

Interpretation of Cluster Results. The findings of the second cluster analysis, like those of the first, do not support the utility of the original seven diagnostic categories. The weak clustering at the mid-runs of the procedure provide little encouragement for using clinical and etiological variables as the basis of diagnostic categories.

In later runs a major cluster did emerge. On examination, that cluster appeared to be related to Cluster IB in the first analysis. When only those individuals are considered who were subjects in both analyses, 65% of those in Cluster IB were also present in the second cluster, here called Cluster IIB. An overlap of about 55% was found for Cluster IA and those individuals in the second analysis who did not form a cluster.

The similarities between analysis I and II are further illustrated by discriminant analysis. Table 6 shows those variables from the second analysis which differentiate between the main cluster IIB and the unclustered group. Like Cluster IB, IIB has a lower incidence of children coded mentally retarded, emotionally disturbed and with EEG abnormalities. But, in addition, this cluster is defined by a number of other clinical findings.

Table 6. Discriminant Analysis of Clusters From Cluster Analysis II Showing Variables Which Differentiate Between Clusters as The .05 Level of Confidence.

	Frequency of Occurrence In Per Cent	
Variable Name	Non-Cluster IIA N=67	Cluster IIB N=71
High Fevers	34.3	1.4
Left-Handed and Mixed	52.2	12.7
Abnormal EEG	62.7	23.9
Sex (Female)	47.8	12.7
EEG Symmetrical (not left)	19.4	0
Birth Injury or Defect (of any sort)	64.2	36.6
Mentally Retarded	65.7	45.1
Emotionally Disturbed	25.4	9.9

The failure of the second analysis to produce two clusters as did the first is apparently due to the change in the variable set, not the increase in subjects. The additional subjects were distributed about equally between the clustered and unclustered groups. The substantive change in the variable set was the reduction of variables highly correlated with IQ test scores (usually sub-tests). The clustering in the first analysis was possible, apparently, because of the information included in those sub-test variables. This seems to imply that if effective grouping is to be accomplished it will need to be based on variables which reflect cognitive functioning. However, the categories used will need to be drawn with much greater clarity. It seems logical that since we are dealing with a clinical population in which linguistic abilities are almost universally affected, the most useful variables will be based on categories of linguistic and related cognitive performance.

In any case, it appears that the original diagnostic categories used in this study are neither unique, nor homogeneous with respect to measurements routinely collected in the course of clinical evaluation. Consequently, it is concluded that at the present time assessment ought to be aimed at determining individual treatment needs, and not toward assignment of the child to a specific diagnostic category.

SUMMARY

This study tested the validity of diagnostic categories which are frequently used to identify children with severe language disorders. Case history and test data from eighty-two children were used to assign each child to one of seven diagnostic categories. Subsequently, the 82 cases were regrouped on the basis of 32 clinical variables using a step-wise clustering procedure. The seven original categories collapsed to only two definable clusters. A repetition of the analysis using a larger sample and different variable set resulted in similar clusters. The variables which define these clusters are discussed, as well as the resulting implications for assessment procedures in general.

FOOTNOTES

1. For the most part, this paper comprises Chapter 2 of "Longitudinal Studies of Linguistically Deviant Children", a Final Report for NINDS Grant NS07514 from the National Institute of Neurological Diseases and Stroke. Additional major support was obtained from a research grant from the United Cerebral Palsy Foundation.

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APPENDIX

SOURCES OF INFORMATION FOR VARIABLES IN CLUSTER ANALYSIS I

MEDICAL

1 & 2. Pre-, para-, and post-natal: number of pregnancies, miscarriages, still births, health during pregnancy, toxic factors, birth trauma, RH imcompatibility, precipitous delivery, pre-mature birth, post-term, comparison with other pregnancies, other unusual features

Illnesses and accidents: rubella, anoxia, encephalitis, meningitis, viral infections, respiratory ailments, mumps, high fevers, convulsions, ear aches, surgery, measles, allergies, hospitalizations, infected tonsils, and adenoids, narcolepsy, falls, concussions, colic, diarrhea, chicken pox

3. Sensory: early responses to sound, ability to focus and follow, evidence of visual dysfunction, evidence of auditory handicap, estimate of auditory ability

6 & 7. Motor: handedness established, sitting-age, standing-age, walked-age, climbing, estimate of motor ability (retarded or precocious), laterality

4,5,8 & 9. Based on direct test and neurological examination

IMPAIRED PSYCHOLOGICAL FUNCTIONING

Key:
SB = Stanford Binet
LI = Leiter International Performance Scale
WISC = Wechsler Intelligence Scale for Children
MP = Merrill-Palmer Scale
ITPA = Illinois Test of Psycholinguistic Abilities

10. Visual Discrimination-Form
    Frostig-Figure-ground
    Frostig-Form Constancy
    III-6,3 Disc.anim.pict.SB
    IV, 2 Disc. forms L.I.
    IV, 5 Disc. forms SB
    VII,1 Recon. sigma L.I.
    VIII, 2 Form disc. L.I.
    VIII, 3 Judging mass L.I.

    Visual Discrimination-Color
    III-6,5 Sorting buttons SB
    V,2 colors L.I.
    VIII,1 Shades gray L.I.
    IV,1 Form, color, no. L.I.
    IX, Form, color L.I.

11. Spatial Rel. (Form & Size)
    III,3 Block Bridge SB
    III-6,2 Pat. Pict. SB
    V,6 Pat. Rect. SB
    IX,1 Paper Cutting SB
    X,2 Block counting SB
    X,3 Concealed cubes I. SB

12. Spatial Rel. (Form & Size
    Color Pattern)
    Block Designs WISC
    Arthur Sten.Des. Test I
    III,2 Block Designs L.I.
    V,4 Block Designs L.I.
    VI,4 Block Designs L.I.
    IX,3 Block Designs L.I.
    X,2 Block Designs L.I.
    X,4 Block Designs L.I.
    XII,1 Block Designs L.I.

13. Visual Memory-Sequencing
    III,4 Picture Memor. SB
    IX, Memor. for designs SB
    Raven Prog. Matrices B & AB
    VI,1 Analog.Prog. L.I.
    VI,2 Pattern Compl. L.I.
    VII,2 Circle Series L.I.
    VII,3 Circum.Series L.I.
    VIII,4 Series Radii L.I.
    IX,1 Dot Estimation L.I.

14. Body Image
    Goodenough
    Manikin-WISC
    Manikin-MP
    V,1 Pict. Compl. SB

15. Abstract Categorization-Nonverbal
    Frostig-Position in Space
    V,1 Genus
    VI,3 Matching Use L.I.
    VII Age Differences L.I.
    IX Analogous Designs L.I.
    XII Facial Expres. L.I.
    XII,2 Similarities L.I.
    XII,4 Class. Anim. L.I.
    Columbia Mental Maturity

16. Fine Motor Expression
    Frostig eye-motor
    Bender Gestalt
    Coding WISC
    III,1 Beads SB
    III,5 Circle MP
    III,6 Vertical Line SB
    V,4 Copy Square SB
    VII,3 Copy Diamond SN
    Opp. Thumb & Finger MP
    Buttoning MP
    Cross MP
    Star MP
    Pegboard I MP
    Pegboard II MP

17. Vocabulary-Ident. & Reasoning
    Peabody Pict. Vocab.
    Ammons Full Range PVT
    III-6, 1 Compballs BIG SB
    IV,4 Pict. Ident. SB
    IV-6,1 Aesth. Comp. SB
    IV-6,5 Commissions SB

18 & 19 Vocabulary-Comprehension &
    Auditory Discrimination
    V,3 Definitions SB
    VI,1 etc. Vocab. SB
    X,3 Abstract Words SB
    Vocabulary WISC

18 & 19. (Continued)
Similarities WISC
VI,2 Differences SB
VII,2 Similarities SB
VIII,4 Sim. & Diff. SB
IV,3 Opp. Anal. SB
IV-6,2 Opp. Anal. SB
VI,5 Opp. Anal. SB
VII,5 Opp. Aral. SB
III-6,6 Comprehension I SB
IV,6 Comprehen. II SB
IV-6,6 Comprehen. III SB
VII,4 Comprehen. IV SB
VIII,3 Verbal Absurd. I SB
VIII,5 Comprehen. V SB
IX,2 Verbal Absurd. I SB
IX,4 Rhymes SB
X,4 Finding Reasons SB
WISC-General Comprehen.

20. Immediate Recall-Sequencing
Aud-Vocal Seq. ITPA
Memory Sentences SB

21. General Verbal Formulation
IV-6,4 Materials SB

21. (Continued)
VIII,6 Name days SB
Action agents MP
General Information WISC
V,3 Definitions SB
VI,1 Vocabulary SB etc.
IV,3 Opp. Anal. SB
IV-6,2 Opp. Anal. SB
III-6,6 Comprehension I SB
IV,6 Comp. II SB
IV-6,6 Comp. III SB
Simp. Quest. MP
IV-6,4 Comp. SB
Action Agents MP
III-6,4 Resp. Pict. SB
VI Resp. Pict. SB
VII,1 Pict. Absurd. SB
Vocal Encoding ITPA

22. Mathematical Reasoning
III,3 No. Discrim. L.I.
IV, 3 Counts 4 L.I.
VI,4 No. Concepts SB
IX,5 Making Change SB
Arithmetic WISC

GENERAL

23. Articulatory deviations were assessed with standard inventories, elicitation of speech by pictures and play situations.

24. Adequacy of the oral mechanism was determined as part of the the medical-neurological examination, as well as by history of feeding, sucking, swallowing, regurgitation, chewing behaviors.

25. Impaired motor encoding was judged on the basis of composite scores obtained on motor subtests listed above under psychological functioning.

26. Impaired social development was assessed by informant responses to the Vineland Test of Social Maturity as well as independent reports of the child's development of the following behaviors: toilet training, self dressing, eating habits, personal hygiene, sleeping habits, peer relationships, degree of relatedness to siblings, parents, relatives, friends, ability to share, play habits (favorite toys and games), personal traits, temper tantrums, degree of cooperativeness, ability to establish rapport, degree of physical contact (with objects, with persons).

27. Adequate intelligence was assessed as a composite of overall performance (full scale scores) on the various tests of intellectual function listed above under psychological functioning.

28. Early sound production assessed by informant report of prelingual activity (crying, laughing), early sound making history (babbling, echolalia), child unusually noisy? child unusually quiet? first words - age, how were first words evoked? types of words? complexity? play "noises" sound imitation, estimation, estimate of comprehension, gesture language, how does child express needs, degree of intelligibility

29 & 32. Autistic manifestations based on clinical observation of degree and type of affect, fears, adjustment to changing situations, ability to attend, distractability, restlessness, hyperactivity, pulls head or ears, head banging, rocking, demands cleanliness, meticulous, thumb-sucking, orderliness, compulsive behavior.

30. Intra-test variability: extreme variation in subtest scores of the same test, usually greater than two standard deviations.

31. Inter-test variability: extreme variability between different tests of intellectual or cognitive function, usually greater than two standard deviations relative to the theoretical distribution.